UNITED STATES PATENT OFFICE

2,024,751

TREATMENT OF ALUMINUM AND ITS ALLOYS

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No Drawing. Application February 14, 1934, Serial No. 711,221

3 Claims. (Cl. 75—58)

This invention is concerned with the treatment of molten aluminum and its alloys, and in particular, it relates to overcoming the deleterious effect of sorbed gas.

In the fabrication of wrought aluminum and aluminum alloy articles it is usually necessary to soften the worked metal by annealing at some intermediate stage in the fabricating operations in order to permit further mechanical working without excessive hardening of the metal. A thermal treatment is also employed to develop high strength in certain alloys subsequent to their fabrication whether in the form of castings or wrought products. Articles subjected to any of the foregoing thermal treatments are frequently found to have small rounded hollow protuberances on the surface. Such imperfections in the surface are not only undesirable with respect to appearance of the treated article, but become exceedingly detrimental to the quality of the product if it is mechanically worked later, by reason of an elongation of the cavities and the formation of flakes or slivers of metal that mar the surface. The formation of the hollow protuberances has in many cases been traced to the presence of gas in the metal. Heating such gassed metal softens it and allows the gas to expand in certain regions with a consequent distention of the upper surface of the cavity thus forming rounded blisters on the surface of the article. The number and distribution of the blisters varies with the conditions favoring the sorption of gas, for example, the manner of melting the metal, the composition of the alloy and the precautions used in pouring the liquid metal into the mold. It has been observed that alloys of the duralumin type that contain magnesium exhibit a strong tendency to sorb gas, which has necessitated extra precautions in handling the molten metal to avoid the introduction of gas as much as possible.

The rejection of articles that have blistered in thermal treatment causes a large economic loss in production since the articles have been either partially or completely fabricated at the time of treatment. The work put into the fabrication up to that point is, therefore, a complete loss if the thermally treated product is rejected. The loss is furthermore intensified in commercial operations through inability to detect the presence of gas in the metal, which gas later causes blisters.

The insidious and elusive nature of the sorbed gas in aluminum alloys has invited many efforts to avoid its introduction or to effect its removal once it has gotten into the metal. The problem of preventing sorption is rendered more difficult by reason of the small amount of gas involved and the extreme tenacity with which such minute quantities are held, particularly the last traces, when complete elimination is attempted. Melting the metal under a vacuum has been tried with some degree of success but this method of preventing contact with the air by the liquid metal is not practicable on a commercial scale because of the expensive equipment required and the limited capacity for handling a large quantity of metal. Fused salt fluxes have been used for the purpose of excluding air from the metal bath and for absorbing any oxide particles suspended in the melt. Chemical compounds yielding volatile substances in contact with the molten metal have been employed in combination with fused salts with varying degrees of success, but none have reached commercial success in the elimination of blisters from thermally treated products.

The use of a fused flux cover is attended with certain disadvantages such as the necessity of raising the temperature of the molten metal above the range ordinarily used in order to obtain the desired degree of fluidity in the fused salt and render it effective as a flux. Salt coverings on liquid metal baths often attack the container and leave a crust or ring of refractory material around the wall which can only be removed with difficulty or possible damage to the container. Some salts give rise to obnoxious fumes that may attack the metal equipment in the foundry or be disagreeable, if not dangerous, to the workmen. In using a salt flux it is also essential that it be absolutely dry before placing it on the metal bath to avoid explosions. Finally, the salt covering must be carefully skimmed from the metal previous to pouring in order to prevent entrapment of any non-metallic particles in the cast article.

The passage of various inert or active gases through the molten metal has been tried in an effort to obviate the difficulties incident to the use of salt fluxes referred to hereinabove. Treatments of this nature require special equipment for the introduction, control of volume, and removal of exhausted gases. The cost of the necessary equipment, its operation, and the failure of the method at times to remedy the trouble, have militated against the wide adoption of the practice.

One of the objects of my invention is to eliminate blisters or sub-surface cavities caused by the presence of gas in thermally treated aluminum and its alloys. Another object is to prevent the occurrence of the aforesaid blisters without recourse to special equipment or practices disclosed hereinabove. A further object is the discovery of a treatment which is economical and convenient and in which is employed a substance which does not pick up moisture on contact with the atmosphere.

I have discovered that the formation of surface blisters, resulting from the presence of sorbed gas, which blisters appear on aluminum articles subjected to such thermal treatments as annealing or solution heat treatment, may be prevented by treating the molten metal with sodium fluoborate previous to casting. From about 0.05 to 5 per cent by weight of the fluoborate with respect to the weight of the metal treated should be used. Within these proportions my purpose is effectively accomplished, an additional amount of the salt being no more efficient, and even wasteful of the material.

Sodium fluoborate is markedly superior to the salt fluxes heretofore employed for improving aluminum and its alloys. Its peculiar properties which so admirably adapt it to use in molten aluminum and its alloys are not possessed by other alkaline fluoborates. The latter compounds in one or more respects fail to meet the requirements of a satisfactory salt for my purposes. Sodium fluoborate reacts at the temperatures commonly used in melting aluminum and its alloys, namely, less than about 800° C. The reaction occurs rapidly, but not violently enough to endanger the foundry workers. The residue obtained from the reaction is light and fluffy, and is easily skimmed off the liquid metal. This feature is in pronounced contrast to the dusty, gummy or sticky product obtained from the action of the usual salt flux. The fumes arising from the fluoborate reaction are neither noxious to the workmen nor injurious to the foundry equipment. I have also determined that the fluoborate reaction leaves substantially no metallic constituent in the aluminum or the alloy. I have detected no increase in the sodium content of the metal treated, and only a minute trace of boron. In this respect sodium fluoborate is ideal for the treatment of high purity aluminum since the salt does not introduce any impurities worthy of notice. A further advantage incident to the use of this particular salt is its anhydrous character; it does not take up any moisture from the atmosphere and thus necessitate a preliminary drying operation previous to its addition to the molten metal. It furthermore need not be stored in special air tight containers to avoid contamination by the atmosphere or loss of any constituent through volatilization or reaction by contact with the air.

The sodium fluoborate may be added directly to the metal bath without the use of any auxiliary flux or material designed to dissolve the fluoborate or products derived from the reaction. The salt should be submerged in the metal, and preferably held at the bottom of the metal charge by suitable means until the reaction has subsided. A few minutes should be allowed for any residues to come to the surface after the reaction has been completed. It is not necessary to stir the metal to bring any non-metallic particles to the surface. It is preferable to agitate the metal as little as possible in order to prevent the introduction of air in the treated bath.

The amount of fluoborate required to treat a given charge of metal depends upon the melting practice employed, the quantity and cleanliness of scrap metal used, and the composition of the final alloy. The correct amount that should be used in a particular case may be easily determined by a few simple tests under the prevailing conditions. I have found that from about 0.05 to 5 per cent by weight of sodium fluoborate with respect to the weight of the metal treated, effectively decreases or entirely prevents the formation of blisters on the heat treated articles. My preferred practice is, however, to employ from about 0.1 to 2 per cent of the salt.

The temperature of the molten metal may vary within wide limits and still allow an effective action by the sodium fluoborate. The reaction generally proceeds more rapidly as the temperature of the metal increases. It has been my experience that temperatures between about 725 and 800° C. are best adapted to the use of the fluoborate.

As a particular example of the improvement gained through treatment of the molten metal with sodium fluoborate, the case of treating a duralumin type of alloy may be cited. A heat of an alloy containing about 4 per cent copper, 0.5 per cent magnesium, 0.5 per cent manganese, with the balance chiefly aluminum, was melted, cast and rolled to 14 gauge (0.064 inch) sheet according to the usual practice. Another heat was made of the same alloy under identical conditions, but the metal was treated with about 1 per cent of sodium fluoborate before casting. This heat was rolled to sheet form as in the case of the previous alloy. Sheets from both heats were then heat treated at about 510° C. for the customary length of time and quenched. Examination of the sheets showed a number of blisters on the alloy which had not been treated with the fluoborate, while the fluoborate-treated alloy developed no blisters.

The fluoborate treatment has also been found to be very effective in reducing the blisters on high purity aluminum sheet. Aluminum of very high purity is more susceptible to the sorption of gas than the metal of ordinary or commercial purity, and it is difficult to rid the metal of this gas to the extent of preventing any blisters on the annealed sheet.

The term aluminum as used herein and in the appended claims refers to the commercially available metal containing the usual impurities whether in small amount as in high purity metal or in larger amount as in aluminum of ordinary purity. The term aluminum base alloy signifies those alloys containing 50 per cent or more of aluminum.

I claim:

1. A method of preventing the formation of blisters due to the presence of gas in thermally treated aluminum and aluminum base alloys, comprising treating the molten metal prior to casting with from about 0.05 to 5 per cent by weight of sodium fluoborate.

2. A method of preventing the formation of blisters due to the presence of gas in thermally treated aluminum and aluminum base alloys, comprising treating the molten metal prior to casting with from about 0.1 to 2 per cent by weight of sodium fluoborate.

3. A method of preventing the formation of blisters due to the presence of gas in thermally treated aluminum and aluminum base alloys, comprising treating the molten metal at a temperature of from about 725 to 800° C., prior to casting, with from about 0.05 to 5 per cent by weight of sodium fluoborate.

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